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Increasing Native Species Biodiversity: Invasive plant species suppression in Esquimalt Gorge Park, Victoria, BC.

Abstract:

Many natural areas in BC are currently facing problems with invasive plant species. Invasive plants can drastically lower biodiversity in parks, which can have a negative effect on many other species such as insects and birds. This study investigates how removal and suppression of invasive plant species can benefit biodiversity. Specifically, it aims to determine how the removal of invasive plants and introduction of native plants will affect the overall biodiversity of the area, focusing on pollinating insects and birds. In this context, invasive species are defined as an introduced organism that negatively alters its new environment in relation to native species. It is known that introduced species can increase some forms of biodiversity, but in this study we focus on species that have an overall negative effect on biodiversity such as grasses, Himalayan blackberry, and weedy plants. We performed a biophysical inventory of the study area before invasive species removal to establish baseline knowledge of the site's species composition, and conducted native species planting after removing invasives. Photo monitoring was conducted to record the invasive species removal and analysis and monitoring will be established to evaluate the hypothesis.

1.0 Introduction:

1.1 Site Description

The restoration area is located on the unceded Lekwungen territory of the Esquimalt and Songhees Nations. This site is on the southern tip of Vancouver Island within the Coastal Douglas-fir biogeoclimatic zone of the moist maritime subzone (CDFmm). This area is characterized by a Mediterranean climate in the rainshadow of Vancouver Island and Olympic Mountains creating warm, dry summers and mild, wet winters. The annual mean temperature of the area ranges from 9.2ºC to 10.5ºC. Mean annual precipitation varies from 647 to 1263mm, with very little (5%) falling as snow from November to April. Most snow melts within the week of falling. Located along the Gorge Waterway of the Esquimalt municipality, the study site is

located at sea level, a mere 370 metres up the Gorge Creek from the saltwater of the Gorge Waterway making the restoration site adjacent to a brackish waterbody.

Figures 1-4: Photos of the site before restoration work began.Photos taken by Bryn Armstrong

Figures 5-8: Photos of the site after invasive species removal and native species planting.Photos taken by Bryn Armstrong

2.0 Methods:

2.1 Study Site Selection

The restoration site lies alongside the previously restored Gorge Creek next to the recent GWAS Pollinator Meadow restoration site. The selected site will be located below the pollinator meadow, bounded between the chip trail and Gorge Creek. This location is found near the southern boundary of EGP. The proposed site baseline extends 300° NW, approximately 48 metres from the Esquimalt Parks Maintenance Bridge to the man-made rock drainage. This creates a rough rectangle of approximately 500m^2 (Figure 9.) The dominant species present are invasive grasses that have created dense mats of non-native biomass amongst the remaining native species of the site. The dominant native species of the site is Nootka rose (*Rosa nutkana*).

Within the study site there were native, exotic, and invasive species present. Of the 29 species present, 15 were identified as native - roughly 50% - while the rest were either exotic or invasive and in far greater abundance. The invasive species are of primary importance for removal due to the risk of colonizing disturbed areas. The western side of the site is largely protected from further invasion of species due to the presence of a Garry Oak ecosystem, while the eastern margin is protected by a gravel pathway. The northern edge is a chip trail that delineates the edge of the study site and further acts as a barrier to invasion while the southern border is the Gorge Creek.

2.2 Biophysical Inventory

A biophysical inventory of the entire riparian area was conducted to determine species diversity and abundance based on the total percent ground coverage of each species. The northeastern site boundary footpath acted as the transect baseline, which spanned 45m along a 300° northwest trajectory from the riparian area (-8m mark at 48°26'41.5"N 123°24'20.9"W). Using a 30m measuring tape, transects extended 90 degrees off the baseline at 4m intervals. There were 11 transects total, ranging in length from 8m to 12m (Figure 9); length variation is due to the nonuniform stream boundary.

Figure 9. Approximate transect locations for the biophysical inventory. Satellite image from Google Earth.

The biophysical inventory employed an alternating belt transect survey method. This was used to analyze total percent ground coverage. A 1x1m PVC quadrat frame was placed on the ground starting at the -12 to -13m markers starting on the left side of the transect line. All species within the quadrat were identified and ground cover abundance was recorded. The quadrat was then placed on the opposite side (left) of the transect line at the 1-2m markers and the recording process done again; this pattern of alternate recording occurred for the entire transect length. Each quadrat area totaled 100 percent; therefore, the sum of individual species coverage within each had to equal 100 percent. For the purpose of this study, soil, decomposing organic matter, and/or coarse woody debris were classified as 'bare ground', and 'grass' represents all grass species observed and classified together. The following information was recorded for each quadrat: plot number, distance along transect (meters), species observed, and percent ground coverage. Data from each transect were then input into Microsoft Excel. Total sample space was determined by multiplying quadrat area by the total number of quadrats (i.e. total sample space = quadrat area x number of quadrats = $1m^2$ x 84 = $84m^2$ out of a total $500m^2$ site). All species in the biophysical inventory were identified using the *Plants of Coastal British Columbia including Washington, Oregon & Alaska* by Pojar & Mackinnon.

2.2.1 Transect Data Analysis

Upon analyzing the baseline biophysical inventory data collected by alternating belt transect, we determined that the vast majority of species present were invasive grasses. The native shrubbery, primarily Nootka rose and common snowberry, was inundated with invasive grasses and common vetch. Grass species, Nootka rose, common snowberry, and common vetch were the four most prevalent species identified within the restoration site. Therefore, the goal remains of removing the invasive and exotic species for the benefit of native species.

2.3 Community Outreach

Community outreach for this project was achieved upon completion of the project in the form of educational pamphlets. Two types of pamphlets were created: some describing the importance of native species in comparison to invasive species and others describing the interconnection between plants, insects, and the endangered western purple martin. Ten native species pamphlets were created to describe identifiers of each species, their edible nature, Indigenous uses, and species use. Together, these pamphlets will be displayed in the Gorge Waterway Nature House for guests to read. The goal of the pamphlets is to educate the public on the importance of native species in their environments and promote the use of native species in parks and personal gardens. The use of native species promotes biodiversity, the main goal of the project, which in turn increases ecosystem resilience.

3.0 Results:

3.1 Biophysical Inventory

The alternating belt transect analysis of the riparian site adjacent to Gorge Creek conducted on January 20th and January 21st 2021 provided the results below. Of the four most abundant species, only the Nootka rose and common snowberry were native. The most prevalent species were invasive grasses, followed by common vetch.

Table 1: Species observed, listed in order of highest relative abundance / ground coverage through to least abundance. Native species are indicated with (***) to highlight their abundance relative to non-native species.

Common Name	**Scientific Name**	**Native, Exotic & Invasive**
Grass Species	-	Invasive
Nootka Rose	*Rosa nutkana*	Native***

Common Snowberry	*Symphoricarpos albus*	Native***
Common Vetch	*Vicia sativa*	Exotic
Creeping Buttercup	*Ranunculus repens*	Exotic
Trailing Blackberry	*Rubus ursinus*	Native***
Himalayan Blackberry	*Rubus discolor*	Invasive
Bigleaf Maple	*Acer macrophyllum*	Native***
Hooker's Willow	*Salix hookeriana*	Native***
Red Alder	*Alnus rubra*	Native***
Dovefoot Geranium	*Geranium molle*	Exotic
Entire-leaved Gumweed	*Grindelia intergrifolia*	Native***
Douglas-fir	*Pseudotsuga menziesii*	Native***
Wild Carrot	*Daucus carota*	Exotic
Wild Teasel	*Dipsacus fullonum*	Invasive
Oxeye Daisy	*Leucanthemum vulgare*	Exotic
Red-flowering Currant	*Ribes sanguineum*	Native***
Sweet-scented Bedstraw	*Galium triflorum*	Native***
Garry Oak	*Quercus garryana*	Native***
White Clover	*Trifolium repens*	Exotic
Common Dandelion	*Taraxacum officinale*	Exotic
Ribwort Plantain	*Plantago lanceolata*	Exotic
Canada Thistle	*Cirsium arvense*	Exotic
Wild Garlic	*Allium vineale*	Exotic
Witches Butter	*Tremella mesenterica*	Native***

Shore Pine	*Pinus contorta*	Native***
Mosses	*Bryophyta*	Native***
Oceanspray	*Holodiscus discolor*	Native***

4.0 Discussion:

The main goal of this restoration project was to suppress invasive species in order to encourage native species. This was achieved through multiple invasive species removal field days. In total, the invasive species removal took 23.5 hours with an average of 2.14 people. This equated to 50 hours of individual effort creating an area efficiency of 5.5m^2/hr and a biomass removal efficiency of 0.32m^3/hr. An estimated area of 275m^2 of a total 500m^2 was treated. The remaining area was either dense Nootka rose and snowberry thicket, or adjacent to Gorge Creek, which was left undisturbed to prevent additional sediments from entering the creek.

Table 2: Condensed data of invasive species removal at the Esquimalt Gorge Park riparian restoration site.

Date	**Removal Time (hrs)**	**People Present**	**Estimated Area Cleared (m^2)**	**Estimated Biomass Removed (m^3)**
Feb. 4, 2021	5	2	65	2
Feb. 9, 2021	3.5	3	40	2
Feb. 23, 2021	2	2	40	2
Feb. 24, 2021	3.5	2	40	3
Feb. 25, 2021	3	2	40	3
Mar. 3, 2021	4.5	2	10	1
Mar. 10, 2021	2	2	40	3
	Total Time Spent (hrs)	Average People Present	Total Area Cleared (m^2)	Total Biomass Removed (m^3)
	=23.5	=2.14	=275	=16
Calculations:	**Total Person Hours:**		**Area Efficiency:**	**Biomass Efficiency:**
	Total Person Hours = total time x average people = 23.5 x 2.14 = 50 hours		Area Efficiency = total person hours / area cleared = 275m^2 / 50hr	Biomass Efficiency = total biomass removed / total person hours = 16m^3/ 50hr

		= 5.5m^2/hr	= 0.32m^3/hr

Following completion of the invasive species removal, a site was selected for planting native species. This site was determined by the slope, aspect, and reduced abundance of native species within. An area of 2.5m x 3.5m (8.75m^2) was raked for dead biomass and grass was shorn to the roots before being tarped. The tarp was placed on the ground and secured with 12 tent pegs along the outer edge. Wood chips were placed along the edge to prevent air infiltration and at the centre to weigh down the tarp. The site was tarped on March 3rd and left until March 29th. Upon removal of the tarp, it became apparent that the methods were flawed. Grass continued to grow under much of the tarp, with areas of success where the piles of wood chips were placed above the tarp. The increased weight caused a reduction of sunlight, water and air infiltration that reduced the prevalence of the grass beneath.

Due to the limited success of the tarp grass removal method, only half of the tarped area was selected for native species planting. First the grasses were removed manually by digging up the biomass and roots, then placed on a tarp and disposed of in the invasive species pile at the Esquimalt Parks Maintenance Shed. Following the removal, the native species selected for planting were placed in the cleared area.

Table 3. List of native species selected for planting in the restoration site.

Species Name	**Scientific Name**
Coastal Strawberry	*Fragaria chiloensis*
Salal	*Gaultheria shallon*
Salmonberry	*Rubus spectabilis*
Red-Flowering Currant	*Ribes sanguineum*
Coastal Mugwort	*Artemisia suksdorfii*
Small-flowered Forget-me-not	*Myosotis laxa*
Yarrow	*Achillea millefolium*
Pacific Sanicle	*Sanicula crassicaulis*
Western Buttercup	*Ranunculus occidentalis*

4.1 Recommendations

For future invasive species removal, additional resources would be beneficial, beginning with increased access to tools such as a wheelbarrow for transportation of materials, tools, and removed biomass. Secondly, having more personnel resources would significantly increase efficiency. Due to Covid-19 restrictions, community outreach was severely affected, preventing an organized community invasive removal event. In the future, when it is safe, involving the community in invasive species removal would benefit both the restoration project itself and be a worthy mode of public education.

Concerning propagation techniques, our native plant propagation was not as successful as hoped. Many species we planted either did not sprout at all or did very minimally. The watering techniques of heavily spritzing the soil did not fully penetrate beyond the top layer, likely contributing to the unsuccessful growth. When sprouts did grow they only had shallow roots. For future projects we recommend watering outside until the water leaks out of the pots to make sure the soil has been fully saturated. We also recommend using sandpaper or other abrasive material to scuff up the seed coatings prior to planting to make it easier for the seed to absorb water.

In the replanting of the riparian zone at the north side, opposite the Esquimalt Parks Maintenance Bridge, the tarped area proved relatively unsuccessful. Portions of the tarped area successfully killed the grass below but the majority was left unaffected. This was largely caused by the tarp allowing water, sunlight and air to seep through. Future projects would benefit from additional weight on the tarp, as the successful areas had wood chips piled atop.

5.0 Educational and Community Outreach Components:

In association with the restoration project, pamphlets and posters were created for public outreach and education, and are to be presented in the Nature House. A flyer was made focusing on Western purple martins, a threatened bird which has been seen nesting in Esquimalt Gorge Park, including what has caused the species to become threatened, their biology, and their habitat. Another flyer was created which focuses on the differences between invasive and native plants in Esquimalt Gorge Park, how people can identify them, the problems with invasive species, and how to remove them at home.

Another group of flyers were created outlining the edible species of Esquimalt Gorge Park that were planted in the riparian restoration sites. Ten selected edible native species were the subject of informative pamphlets showcased in the Gorge Waterway Nature House. These

pamphlets consisted of general information on each species, their edible nature, Indigneous use, and species use. An example pamphlet is provided in Appendix A below.

6.0 Conclusion:

The end result of this phase in the restoration project was creating an ecosystem consisting primarily of native species. Species were selected for their edible nature, interaction with pollinators, and esthetics. The overarching goal was to support native animals with a high density of native plant species that will attract and support native pollinators within Esquimalt Gorge Park.

In the creation of this native species assemblage, an interactive and educational restoration project was established. This was achieved through the specific species selected, which were chosen to be easily identified by the public and edible. The goal of the pamphlets in coordination with the species is to raise awareness of the interconnected nature of native plants and their importance in the environment. In the future, the public will be able to witness these interactions as pollinators land on native flowers, collect pollen and nectar, and eat the fruits. The public will further be able to watch the species that feed upon the pollinators, notably the Western purple martin, all while foraging along the riparian zone themselves on the edible fruits.

This restoration project will never truly end; monitoring and management will be required in the future. Continued maintenance of invasive species will be required, including invasive species removal and suppression, watering during drought periods, and potentially replanting native species. The goal is to include community participants in the restoration projects of the future. As in restoration, the greater the interconnectedness, the higher the resilience. The more hands we have interested in furthering the restoration project following the same methods laid out in this paper, the greater the chance of success.

7.0 Acknowledgements:

We would like to thank the Gorge Waterway Action Society, with a special thanks to Stephanie Gurney, our Restoration Coordinator, for the opportunity and guidance on our project.

8.0 References:

MacKinnon, A., et al. *Plants of the Pacific Northwest Coast: Washington, Oregon, British Columbia & Alaska*. Lone Pine Pub., 2014.

APPENDIX A: Example of Edible Species Pamphlet

EDIBLE SPECIES OF ESQUIMALT GORGE PARK

SALAL

GORGE WATERWAY NATURE HOUSE

Gorge Waterway Action Society

Salal (*Gaultheria shallon*)

OVERVIEW:

- General Information: Salal has evergreen, shiny, dark-green leaves that are bell-shaped. These leaves have stems that form above them that have white flowers and dark-bluish to purple fruits. It grows to be 0.5-2 metres in height. Salal spreads primarily through underground stems and roots, much like the way the Coastal Strawberry uses 'runners.'
- Habitat: Salal is the most common shrub in the coastal British Columbia area, often found growing in amongst coniferous coastal forests.
- Horticultural Uses: Salal is found in many ornamental gardens and native gardens. It is a primary component of floral arrangements transported worldwide.

Edible Nature

Salal is easily identified by its vigorous, mostly erect, evergreen shrubbery. There are pliable soft hairs on the stems between the large, leathery, thick, glossy, ovular, finely-toothed edged leaves. Urn shaped white or plate to bright-pink flowers hang individually from one side of the stem tips in large clusters and develop into reddish-blue to dark-purple berries. These berries are delicious. Spit out the seeds of the berries to plant more Salal shrubs.

Indigenous Uses of Salal

The berries of the evergreen Salal shrub are a major source of food for the Coastal Indigenous peoples of British Columbia. The berries were often dried and turned into cakes, mixed with other berries. They were often sun dried, pan/oven dried into fruit leathers. The berries were often used as a dye to create dark-blue or purple hues. The branches and leaves were a staple for lining cooking pits and for flavouring various foods. The leaves were further used as a bandage to cover cuts and wounds.

Species Uses of Salal

Salal is often browsed upon by herbivores due to its evergreen nature. It forms dense thickets that often shed the snow during winter months and remains as a viable forage food for the Cervidae family (deer, elk, moose). Smaller mammals and birds use the dense thickets as habitat and nesting areas. The berries of the shrubs are eaten by many species while the flowers are an important source of pollen and nectar for bees, butterflies, and hummingbirds.

Be sure to finds the berries before the birds eat them all!

Salal Neature Question

Question: What is the ecoprovince that Salal is known to grow in?

Answer: Salal is most prominent in the Georgia Depression ecoprovince.

For a full list of information & image sources, visit our website at: http://gorge.ca/ycp-references/

Please see: http://gorge.ca/ycp-references/ for Pamphlet references.

APPENDIX B: Detailed Ground Cover Data For Each Transect

Species Abundance - Transect -3 (12m)	
[species]	[total coverage]
Grass	725%
Creeping Buttercup	120%
Common Vetch	80%
Rock	60%
Wood Chip Path	39%
Wild Carrot	35%
Moss	30%
Hooker's Willow	20%
Nootka Rose	17%
Entire-leaved Gumweed	15%
Dovefoot Geranium	11%
Canadian Thistle	10%
Ribwort Plantain	10%

Common Dandelion	7%
Oxeye Daisy	5%
Trailing Blackberry	5%
Large Woody Debris	5%
Mushrooms	4%
White Clover	1%
Salmonberry	1%

Species Abundance - Transect -2 (12m)	
[species]	[total coverage]
Grass	351%
Common Vetch	125%
Nootka Rose	105%
Creeping Buttercup	100%
Large Woody Debris	30%
Dovefoot Geranium	10%
Entire-leaved Gumweed	10%
Unknown Aquatic Species	10%
Himalayan Blackberry	5%
Ribwort Plantain	5%
Wild Carrot	5%
Bare Ground	5%
Oxeye Daisy	5%

Common Dandelion	2%
Field Bindweed	2%

Species Abundance - Transect -1 (12m)	
[species]	[total coverage]
Grass	438%
Common Vetch	115%
Nootka Rose	45%
Creeping Buttercup	40%
Dovefoot Geranium	20%
Hooker's Willow	10%
Common Dandelion	5%
Wild Teasel	5%
Wild Garlic	4%
Shore Pine	2%
Daphne Laurel	1%

Species Abundance - Transect 0 (11m)	
[species]	[total coverage]
Grass	432%
Common Vetch	80%
Creeping Buttercup	75%
Rock	30%
Canadian Thistle	25%

Nootka Rose	22%
Bare Ground	15%
Common Dandelion	12%
Dovesfoot Geranium	7%
Wild Teasel	2%

Species Abundance - Transect 1 (11m)	
[species]	[total coverage]
Grass	270%
Nootka Rose	120%
Creeping Buttercup	45%
Rock	40%
Wild Teasel	25%
Common Vetch	25%
Unknown Aquatic Species	20%
Canadian Thistle	10%
Shore Pine	10%
Common Dandelion	10%
Hooker's Willow	10%
Large Woody Debris	10%

Species Abundance - Transect 2 (10m)	
[species]	[total

	coverage]
Grass	239%
Nootka Rose	125%
Creeping Buttercup	70%
Snowberry	60%
Rock	60%
Canadian Thistle	35%
Moss	25%
Common Vetch	25%
Unknown Aquatic Species	15%
Wood Chip Path	10%
Red Alder	10%
Dovefoot Geranium	5%
Wild Garlic	5%
Wild Carrot	5%
Common Dandelion	5%
Witches Butter	2%
Shore Pine	2%
Wild Teasel	2%

Species Abundance - Transect 3 (10m)	
[species]	[total coverage]
Grass	396%

Woodchip	169%
Rock	100%
Unknown Aquatic Species	65%
Common Vetch	55%
Nootka Rose	36%
Douglas-fir	25%
Moss	25%
Canadian Thistle	20%
Common Dandelion	20%
Bare Ground	15%
Dovefoot Geranium	14%
Large Woody Debris	12%
Wild Carrot	10%
Creeping Buttercup	7%
Wild Garlic	7%

Species Abundance - Transect 4 (9m)	
[species]	[total coverage]
Grass	351%
Woodchip	150%
Rock	80%
Nootka Rose	60%
Creeping Buttercup	55%

Snowberry	45%
Oceanspray	30%
Bare Ground	30%
Common Vetch	25%
Red Alder	15%
Unknown Aquatic Species	10%
Dovefoot Geranium	5%
Wild Teasel	5%
Moss	5%
Canadian Thistle	5%
Common Dandelion	5%
Wild Garlic	2%

Species Abundance - Transect 5 (9m)	
[species]	[total coverage]
Rock	270%
Grass	110%
Woodchip	95%
Unknown Aquatic Species	55%
Nootka Rose	30%
Common Vetch	11%
Entire-leaved Gumweed	10%
Dovefoot Geranium	5%

Unknown Species #1	5%
Creeping Buttercup	5%
Moss	4%

Species Abundance - Transect 6 (8m)	
[species]	[total coverage]
Woodchip	82%
Grass	74%
Nootka Rose	65%
Moss	32%
Unknown Aquatic Species	30%
Entire-leaved Gumweed	10%
Common Vetch	7%

Species Abundance - Transect 6 (9m)	
[species]	[total coverage]
Grass	504%
Woodchip	120%
Common Vetch	64%
Nootka Rose	45%
Creeping Buttercup	37%
Wild Carrot	35%

Dovefoot Geranium	21%
Garry Oak	5%
Unknown Species #2	5%
Common Dandelion	5%
Mushroom	5%
Tall-Oregon Grape	2%
Red Dead Nettle	2%